AD-A064 878 DAVID W TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CE--ETC F/G 11/1
SPECIFICATION FOR FILLED-PTFE SLEEVE-TYPE PISTON SEALS FOR HIGH--ETC(U)
FEB 79 R M GIANNINI, H J SKRUCH

UNCLASSIFIED DTNSRDC-TM-27-78-96 NL

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IN REPLY REFER TO:
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14 FEB 1979

(12) (11)

From: Commander, David W. Taylor Naval Ship R&D Center
To: Commander, Naval Sea Systems Command (SEA 0331)

Subj: Specification for Filled PTFE Sleeve-Type Piston Seals for High-Pressure Oil-Free Compressors; DTNSRDC TM-27-78-96, forwarding of

Encl: (1) Report DTNSRDC TM-27-78-96

1. Enclosure (1) is a specification describing materials, manufacturing, and quality assurance procedures and end-product requirements for sleeve-type piston seals currently used in Navy high-pressure oil-free air compressors. It is considered to be comprehensive, complete, and fully validated. The Koppers Company, Engineered Metal Products Group, Baltimore, MD, the only company which has manufactured sleeve seals for Navy compressors, has manufactured several hundred sleeve seals which have met all the physical requirements of the specification. The complete specification was recently reviewed with them and their comments have been reconciled. The Koppers Company is therefore considered to be capable and willing to deliver sleeve-type piston seals which fully comply with the requirements of enclosure (1). The Navy may want to consider paying the costs to establish a second source of sleeve seals including extensive compressor tests to verify operating performance.

2. It is recommended that the requirements of enclosure (1), either in the form of the present document or incorporated into a MILSPEC, be invoked when sleeve seals are purchased by any Navy supply activity or supplied by original equipment manufacturers in new compressors or directly to the Fleet as spares. It is pointed out that sleeve seals are deceptively simple in appearance thereby obscuring and belieing their relatively high costs which reflect the demanding manufacturing and quality assurance procedures which are essential to obtaining satisfactory compressor performance. It is most essential that purchasing agents not be allowed the liberty of "saving the Government money" by buying inexpensive look alikes which were not manufactured to the exacting requirements of enclosure (1).

A. J. ARGIRO
By direction

Copy to:
NAVSEA (SEA 04801)
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DDC (12)

(12) (11) LEVEL II

(6) SPECIFICATION FOR FILLED-PTFE SLEEVE-TYPE
PISTON SEALS FOR HIGH-PRESSURE
OIL-FREE COMPRESSORS

By

(10) Robert M. Giannini ~~and~~ Harry J. Skruch

ABSTRACT

Specifications covering material ingredients, fabrication, and testing of filled polytetrafluoroethylene sleeve-type piston seals for shipboard oil-free compressors are provided. Procedures for blending, molding, and assuring material quality are described.

(12) 34 p. (11) 14 Feb 79

(14) DTNSRDC-TM-27-78-96

1.0 SCOPE AND CLASSIFICATION

1.1 Scope

This specification covers premium quality PTFE* material containing specific fillers for use as high-pressure, self-lubricating sleeve seals. Quality assurance provisions described herein may be adapted for use in other self lubricating seal designs.

1.2 Classification

The seal material is 35 percent chopped copper wire and 10 percent glass-fiber-filled PTFE (percent by weight).

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply. American Society for Testing Materials Specifications:

- D618-61 - Conditioning Plastics and Electrical Insulating Materials for Testing.
- D2290 - Apparent Tensile Strength of a Ring or Tubular Plastic by Split Disk Method.
- D1457-62T - PTFE Fluorocarbon Resin Molding and Extrusion Materials.

(Application for copies should be addressed to American Society for Testing Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

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*A list of abbreviations is on page 17.

3.0 REQUIREMENTS (PHYSICAL PROPERTIES)

Basic ingredients to be utilized in fabricating the material are described in Section 1.1 and listed in Table 1. Property values for the material in the as-molded state are shown in Table 2.

TABLE 1 - MATERIAL INGREDIENTS

Ingredient	Size
PTFE particle	10-50 μm average diameter
Glass fiber, Owens Corning milled, No. 739AB, Type E glass free of sizing (or equal)	13 μm nominal diameter. 1/32 inch nominal length.
Wire No. 50 AWG bare soft copper (99 percent pure)	0.032-0.042 inch long

TABLE 2 - PROPERTY VALUES FOR MACHINED (UNSWAGED) SPECIMENS

Property	Material					
	Nominal Diameter Seal, in.					
	7/8	1	1 1/8	1 1/2	1 13/16	2
Apparent Tensile Strength (Minimum) psi (See 4.5.4)	← 1800 →					
Elongation[1] (in/in of I.D.) Minimum (See 4.5.4)	2.50	2.42	2.33	2.09	1.89	1.75
Composition by Weight (See 4.5.6)	Within 1 Percent of Nominal Value					
Specific Gravity[2] (See 4.5.3) Minimum	← 2.96 →					
Maximum	← 3.05 →					
Uniformity (See 4.5.5)	Seal Material Must be Free of Defects as Defined in 4.5.5.					

[1]Elongation values are influenced by the diameter of the ring-type tensile specimens. Linear extrapolation for sizes outside the sizes shown is permitted.
[2]Same values obtained if finished (swaged) seal items are measured.

4.0 QUALITY ASSURANCE PROVISIONS

The procedures outlined below are intended to be exacting in order to produce sleeve seals which very closely replicate the properties of similar sleeve seals made from other batches at other times by other sources.

4.1 Test Responsibility

The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the government. Inspection records of the examination and tests shall be kept complete and available to the government as specified in the contract or order. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Lot

A lot shall consist of 50 items or less. All items in a lot shall be fabricated from the same batch of blended ingredients, compacted in the same uniform procedure and sintered together.

4.3 Classification of Tests

All tests shall be classified as follows:

4.3.1 Lot Acceptance Tests

These tests shall consist of compliance with values in Table 1, composition by weight, and specific gravity (see 3.0).

4.3.2 Item Acceptance Tests

These tests shall consist of radiographic examination of the finished (swaged) seal item and determination of tensile properties of the specimen machined adjacent to the unswaged seal blank (see 3.0 and 6.8).

4.4 Sampling for Tests

Tensile specimens as described in 4.5.1.2 shall be machined from the molded and sintered bar immediately adjacent to and concentric with the seal blanks. Tensile specimens and seal blanks shall alternate with a tensile specimen on each end of the molded bar. As an example, if two sleeve seals are machined from a bar, then three tensile specimens are required - one at either end and one between the sleeve blanks. If five sleeve seals are machined, then six tensile specimens are required.

Each seal item shall be tested for uniformity after swaging (see 4.5.5).

Unless otherwise specified by the purchaser, for each 20 seal items or less in a lot, the specific gravity and filler concentration of at least one seal shall be determined by the procedures in 4.5.1.3, 4.5.3, 4.5.6.

4.5 Test Procedures

4.5.1 Test Specimen Preparation

4.5.1.1 Unless otherwise specified by the procuring agency, the finished item shall serve as the specimen for uniformity and specific gravity tests. No part of the unswaged sleeve seal and tensile specimen shall be made from material within 1/8 inch of the ends or 1/32 inch from the other surfaces of the molded bar from which it is fabricated.

4.5.1.2 Unless otherwise stated by the procuring agency, the specimen for measuring elongation and apparent tensile strength shall be a ring, machined immediately adjacent to and concentric with the seal blanks, and with the same diametral dimensions. Axial thickness is to be 0.187$\pm$ 0.001 inch. Cross-sectional area for strength calculations shall be based on original cross-section dimensions.

4.5.1.3 For determination of chemical analysis, a sample shall be taken from material at least 1/32 inch from any surface of the molded bar from which the seal items are to be fabricated.

4.5.2 Conditioning

Test specimens for specific gravity and elongation and apparent tensile strength shall be conditioned in accordance with procedure A of ASTM D 618-61 for a minimum time period of 4 hours prior to testing.

4.5.3 Specific Gravity

For each 20 items or less, at least one test specimen shall be prepared in accordance with 4.5.1 and 4.5.2 and tested in accordance with the method A1 in ASTM D 792. This procedure is an immersion technique that requires the use of a wetting agent.

4.5.4 Elongation and Apparent Tensile Strength

The tensile specimen shall be prepared according to 4.5.1 and 4.5.2 and tested in accordance with ASTM D 2290, Procedure B, with the following exceptions:

- The split mandrel diameter is to be determined by specimen original inside diameter. Diametral clearance between mandrel and specimen should be held to a minimum but should be at least 0.002 inch (i.e., for a tensile specimen I.D. of 0.947±0.004 inch; the split mandrel should be 0.939± 0.002 inch).
- The cross-head speed is to be 1.0 cm/min (0.4-0.5 in/min).
- The apparent tensile strength (pounds per square inch) is to be computed from the maximum recorded load and the original cross-sectional area of the specimen. The average tensile strength will be computed from the number of specimens along the bar of material, and this number will be the tensile

strength associated with each seal from that bar in accordance with Table 2.

• Elongation (inch/inch) will be computed by dividing crosshead movement, from full specimen contact to specimen failure, by the original inside diameter of the tensile specimen. The average elongation will be computed from the number of specimens along the bar of material and this number will be the elongation associated with each seal on that bar in accordance with Table 2.

4.5.5 Uniformity

Each seal is to be examined, after fabrication, with X-ray radiography to determine the existence of defects (voids, inclusions, or nonhomogeneous filler distribution). Each seal shall have a permanent surface mark on the unradiused end which can be used to index the sleeve during the radiographic procedure. Exposures shall be referenced according to the position of the surface mark and shall be taken using procedures described in the appendix. Exposure and development shall be in accordance with commercial practice adequate to ensure a clear, contrasting exposure of proper density. The presence of any defect within 7/16 inch of the radiused end of the seal shall be cause for rejection. Exposures of material of known quality are shown in the appendix.

4.5.6 Composition

The concentration by weight of each filler (metal and glass) in the sample mentioned in 4.5.1.3 shall be determined. Any method which offers ± 1 percent accuracy may be used, but direct chemical analysis is suggested.

4.5.7 Swaging

All sleeve seals shall be swaged as part of the fabrication process (see 6.8). All sleeve seals of one size, from the same material, swaged and heat treated together should

exit the swaging tool with the same outside diameter. As an example, if a nominal 7/8-inch-diameter size sleeve seal with a wall thickness of about 10 percent of its unswaged outside diameter is heat treated for two 1-hour cycles at 530 F in a swaging tool with a wall thickness of approximately 1/4 inch, cooled down to room temperature, and removed from the swaging tool, the swaged seal diameter will be approximately 0.003/ 0.004-inch less than the swaging tool inside diameter. A larger or smaller outside swaged diameter indicates an error in the heat-treat temperature which may adversely affect seal performance.

4.6 Certification

Unless otherwise specified, items furnished to this specification shall be accompanied by a certification which shall include test data verifying tensile, elongation, specific gravity, composition, uniformity, and a statement that no plasticizers or reprocessed material have been used. The certificate shall be presented prior to or at the time of delivery of each lot. It shall be signed by a responsible agent of the certifying organization and shall be accompanied by evidence of the agent's authority to bind his principal. Positive prints of the radiographs required in 4.5.5 may also be required by the purchaser.

4.7 Records

Records of the test results (4.5.3 through 4.5.7), including radiographs, shall be maintained and kept available to the purchaser at least 10 years from date of delivery of the seal items. Each seal is to have a distinct and unique permanent surface identification, near the unradiused end, which will allow test results to be associated with a specific seal item. The identification should not interfere with seal performance.

4.8 Rejection

4.8.1 Examination

Any lot not containing the correct number of properly marked seal items or without required certification (see 4.6) shall be rejected.

4.8.2 Tests

Any item shall be rejected for failure to comply with any of the test requirements in 3.0 when tested in accordance with 4.5.

5.0 PREPARATION FOR DELIVERY

5.1 Packing

Packing shall be in accordance with commercial practice adequate to ensure acceptance and delivery by the carrier for the mode of transportation employed. Containers shall comply with carrier rules and regulations applicable to the mode of transportation.

5.2 Marking

In addition to any specific marking required herein, or by the contract or order, interior and exterior shipping containers shall be marked in accordance with the purchaser's identification.

6.0 REQUIRED MATERIALS AND PREPARATION

6.1 Materials

6.1.1 Chopped Copper Wire

To produce a satisfactory material it is extremely important that the bare, soft, uncoated wire be 0.001-inch-diameter (No. 50 AWG) and 0.032 to 0.042-inch long. Periodic checks on wire length with photomicrographs have shown to be an effective method of inspecting the chopped wire before blending,

see Figure 1. Incorrect wire length will adversely affect material physical properties.

The chopped wire should be cleaned to remove all oil and other surface contaminants using a cleaning procedure which does not leave a residue. "Dirty" wire will adversely effect material physical properties.

It may be advantageous to pass the bulk chopped wire through a high speed impact blender (6.2) to break up any clumps of wire prior to mixing the wire with the remaining ingredients. A single 2-3 second operation of the blender should be sufficient to mix a 100-200 gram batch of wire (6.1.3). (Note: 158.9 grams of wire are required for a 1-pound (454 gram) charge.)

6.1.2 Glass Fibers and PTFE

Virgin PTFE powder must be blended with milled glass fibers according to the proportions shown in Table 3. A preliminary check of elongation and tensile strength proportion of the material is suggested to verify its performance before the chopped copper wire is added to the mixture. Minimum elongation of the unfilled PTFE molded bar should be 4.50 in/in and minimum tensile strength should be 3000 psi.

If preblended glass-fiber-filled PTFE powder mixtures are to be used, they must be blended according to the proportions shown in Table 3. A preliminary check of elongation and tensile strength properties of the materials is suggested to verify its tensile properties before the chopped copper wire is added to the mixture. Minimum elongation should be 4.50 in/in, and minimum tensile strength should be 3000 psi.

6.1.3 Weighting Ingredients

It is suggested that the material be blended in 1-pound charges. Weigh out the proper amount of ingredients for a 1-pound (454-gram) charge of mixture. The material consists of 35 percent chopped copper wire, 10 percent milled glass fibers,

and 55 percent virgin PTFE powder. All percentages are by weight. See Table 3 for weights. Any number of 1-pound charges can constitute a batch. The area where weighing occurs must be clean.

TABLE 3 - SLEEVE SEAL MATERIAL COMPOSITION

Method	Component	Weight by %	Weight gram[1]	Elongation in/in	Tensile Strength psi
1	PTFE	55	249.7	4.50[2]	3000[2] minimum
	Glass	10	45.4		
	Chopped copper wire	35	158.9	-	-
2	5% Glass-fiber filled PTFE	31.24	141.8	4.50 minimum	3000 minimum
	25% Glass-fiber filled PTFE	33.71	153.0		
	Chopped copper wire	35	158.9	-	-

[1]Weight in grams for a 454-gram (1-pound) charge.

[2]Value for 10 percent glass-fiber-filled PTFE molded bar.

6.2 Blender Design

The blender base (drive) should have a free revolution per minute of 15,500 and be rated at approximately 1725 watts, 115-vac, 60 hertz, 15-ampere, single phase, and be comparable to a model from Waring Products Division, Dynamics Corporation of America, set on the low-speed setting, see Figure 2. The upper end of the blender is a fabricated plexiglass container and lid which enables observation of the mixing process, see Figure 3. The plexiglass container should have a mark on the outside corresponding to the height when loaded with a 1-pound charge of material. The aluminum plate bottom acts as a heat sink to remove heat from the blended material and plexiglass. The two blades are specially designed for operator safety and mixing action of the material. Blender blades are made from heat treated Type 455 Carpenter Stainless Steel, see Figure 4.

6.3 Mixing (Blending) Procedure

6.3.1 Step 1

The area where the mixing takes place must be clean, and the ambient temperature should be 68-75 F.

6.3.2 Step 2

Add the glass-fiber-filled-PTFE powder or virgin PTFE and milled glass fibers to the blender (295.1 grams total) and mix for 2-3 seconds. Add 158.9 grams of copper wire to the blender. Operate the blender for 2-3 seconds (see CAUTION in 6.3.5). Place mixed material in a container large enough to hold the batch. Continue to mix all remaining 1-pound (454-gram) charges and deposit in large container. Mix the 1-pound charges into each other manually using a spatula or similar device without compacting the material. Be sure the material has cooled to room temperature before mixing again.

6.3.3 Step 3

Taking material from different areas within the batch container, fill blender to the 1-pound mark on the plexiglass container, see 6.2). Mix for 2-3 seconds. Remove blender container with lid from base and while rotating horizontally shake container allowing material to redistribute. Replace container on blender base and mix for 2-3 seconds. Place material in another suitable container to hold the batch. Continue to mix all remaining material.

6.3.4 Step 4

Repeat 6.3.3 one time.

6.3.5 Step 5

The above suggested procedure will ensure the proper dispersion of the chopped copper wire throughout the glass-fiber-filled-PTFE. When 6.3.2-6.3.4 are completed, the individual copper strands appear PTFE coated, and the overall mixture

appears uniformily "pinkish" in color. CAUTION - blending more than the required 2-3 second duration is detrimental to the ultimate mechanical properties of molded parts made from the mixture.

6.3.6 Step 6

Place mixed material in a suitable vapor proof storage container if it is not to be molded immediately.

6.3.7 Step 7

Records of mixing and material batches are recommended.

6.4 Preparation Prior to Isostatic Compaction

6.4.1 Bar Size Requirements

It has been established that the elongation property of copper-wire and glass-fiber-filled PTFE material is improved if a minimum quantity of material is left on the outside and inside diameters of the tensile specimen and unswaged sleeve seal blanks before sintering. The dimensions prior to isostatic molding should be such that the surfaces of the tensile specimens and unswaged sleeve seals are about 1/32 inch away from the surfaces of the isostatically compacted bar, see Figure 5. The tensile specimens and unswaged sleeve seals should conform to 4.4 and 4.5.1.

6.4.2 Precompaction

The steps for precompacting a hollow cylindrical bar of PTFE are illustrated in Figure 6. Assemble cylinder, bottom washer, and mandrel. Add material to mold and uniformly (during or after addition of about each 60 grams of material) vertically vibrate the apparatus to settle material. Do not physically compact the powder at this time because this will cause a discontinuity within the molded products. Repeat this process until the cylinder is filled. Insert washer in top and compact the material with 50-100 psi. Invert mold and

compact again with same pressure from the opposite side. Carefully remove precompacted mold from cylinder.

6.5 Isostatic Compaction

Install the flexible end caps on the mandrel (see Figure 7) and place in a neoprene elastomeric bag. Plug end and evacuate air from within bag. Place bag in pressure vessel and isostatically compact material at 10,000 psi, coming up to pressure within a minimum of 2 minutes. Let pressure remain on the sample for approximately 2 minutes. Release pressure over a period of 1/2 minute. Remove and examine the molded bar for indication that any of the pressing fluid may have leaked through the elastomeric bag. If there is any such evidence of pressing fluid, the molded bar should be rejected. If a bar of material cannot be molded to the accuracy described in 6.4.1 the green-molded bar should be machined to obtain the dimensional requirements of 6.4.1 prior to sintering, see Figure 8.

6.6 Sintering

Free (unconfined) sinter the isostatically compacted bars at 700 F for 1/2 hour per 1/4 inch of wall thickness (an average wall thickness may have to be used). This should be done in an air atmosphere only. Experience has shown that inert-gas sintering results in seal material which is less ductile. For the free-air sintering process, the material should be placed in the oven and the temperature increased from room temperature to the sintering temperature over a period of 2 hours (minimum) and held at sintering temperature for the required time. At the end of the sintering period the bars should be immediately removed from the oven and cooled in a room-air-atmosphere with normal convection.

6.7 Machining

Machine sleeve seal blanks and tensile specimens from sintered bars is in accordance with 4.5.1. Do not grind as this will embed particles in the surfaces of the finished parts.

6.8 Swaging

A technique known as "swaging" is used to obtain improved sleeve seal operating characteristics and to produce finished diameters. The process as illustrated in Figure 9 consists of forcing an oversize sleeve blank through a tapered die to reduce the outside diameter approximately 21 percent and applying heat cycles so that the seal blank is stabilized at the reduced diameter. For relatively thick wall sleeves the inside sleeve diameter can be finished simultaneously with the outside diameter by inserting a cylindrical mandrel into the center of the seal while the seal is being pushed through the tool. This procedure is applicable for sleeve seals having a finished wall thickness of approximately 10 percent of the unswaged outside diameter. Figure 10 illustrates the swaging tools typically used in the swaging process. As shown, a sleeve with an inside mandrel is prepared for the heat-cycling step. Instructions for Figure 10 provides a detailed procedure for swaging using a mandrel inside the sleeve.

For seals with a thinner finished wall (about 4 percent of the unswaged outside diameter) the use of a mandrel to size the inside of the sleeve is not practical. Therefore, a thicker sleeve-seal blank (i.e., about 10 percent of the outside diameter) is swaged to its correct outside diameter (no mandrel used on inside diameter) followed by heat cycling, stress relieving, and final machining of the inside diameter to obtain the required thinner wall. The heat cycling is usually done at 530 F (277 C) for two 1-hour cycles. Between and after the 1-hour heat cycles the swaged seal is air cooled while still confined within the swaging tool apparatus. Depending on tool wall thicknesses, and sleeve seal blank wall thicknesses, the swaging time may have to be increased to ensure proper heat penetration. Instructions for Figure 11 provides the swaging procedure when not using a mandrel to size the sleeve inside dimension. Figure 11 illustrates the swaging tools typically used in the swaging process without a mandrel. Thin walled

sleeves which require high dimensional stability should be stress relieved at 300 F for 2 hours before final machining so that the expansion due to viscoelastic relaxation takes place prior to installation in the compressor. Information regarding the above process can be obtained from this Center.

6.9 Ordering Data

Purchase orders for sleeve seals should specify the following:

- Title, number, and date of this specification.
- Classification of material to be used.
- Finished seal dimensions.

Purchasers may also specify that positive prints of the radiographs described herein be supplied with the certification, see 4.6.

List of Abbreviations

AWG	-	American wire gage
C	-	Celsius
cm/min	-	Centimeter per minute
F	-	Fahrenheit
i.e.	-	That is
in.	-	Inch
in/in	-	Inch per inch
I.D.	-	Inside diameter
μm	-	Micrometer
No.	-	Number
PTFE	-	Polytetrafluoroethylene
psi	-	Pounds per square inch
psig	-	Pounds per square inch gage
vac	-	Volts alternating current

Figure 1 - 0.001-Inch Diameter Chopped Copper Wire, 0.032/0.042 Inch Long (Photomicrograph of Unblended Chopped Wire (15X))

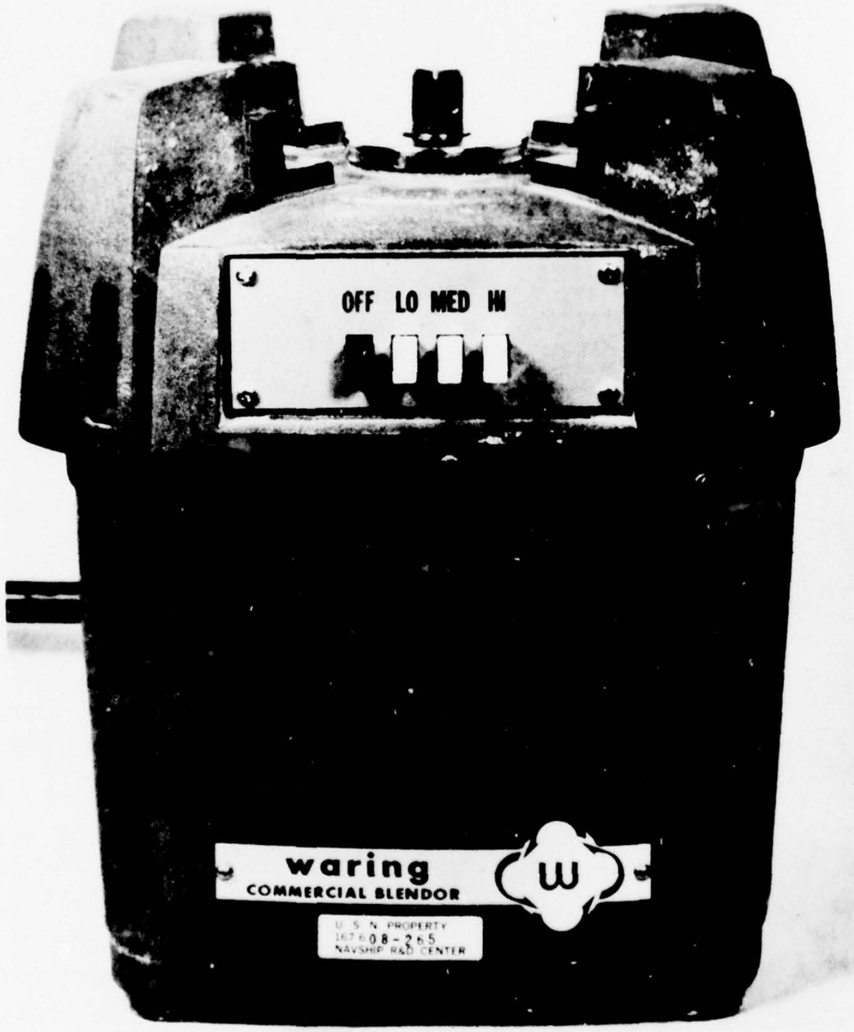


Figure 2 - Blender Base

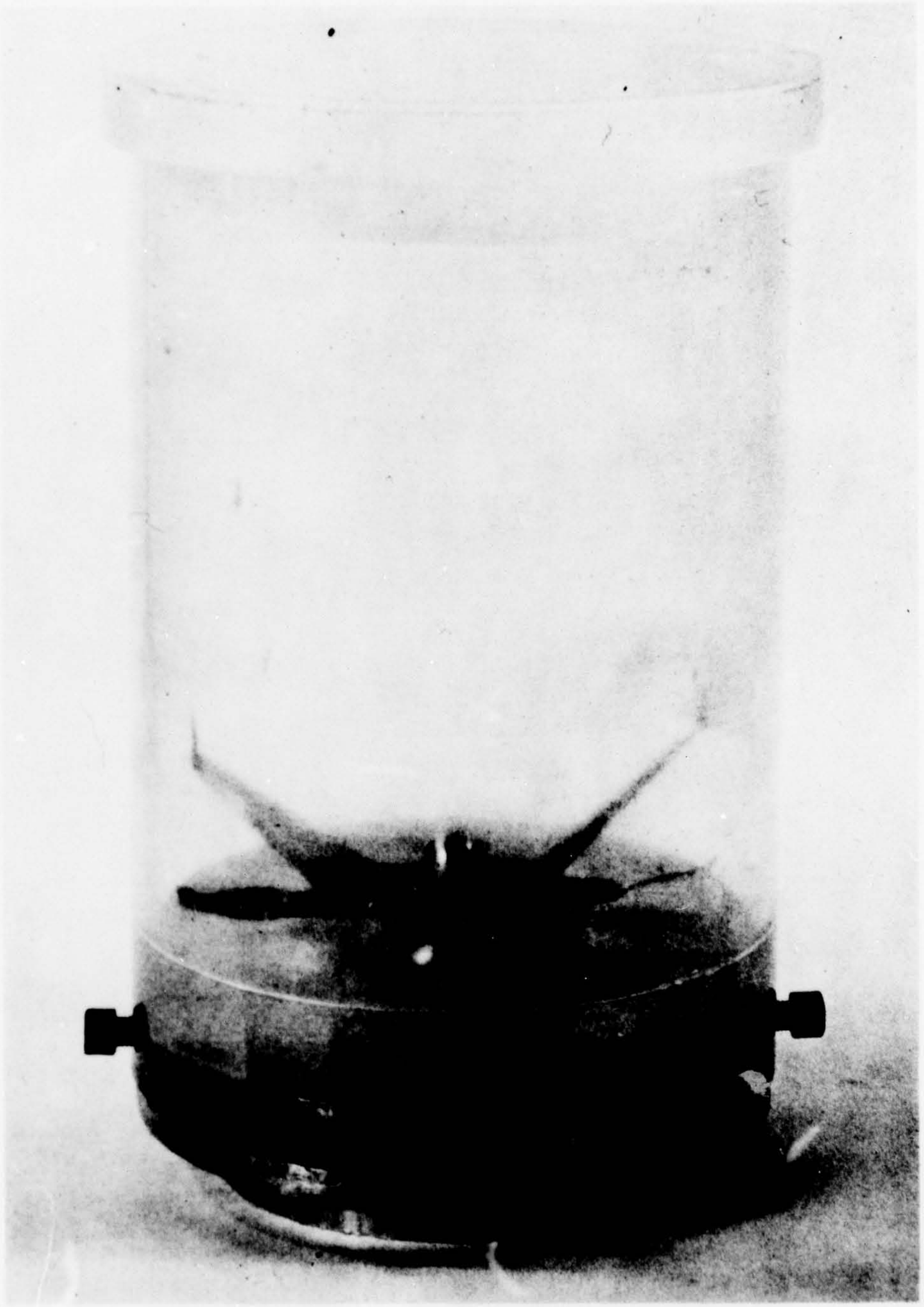


Figure 3 - Blender Container

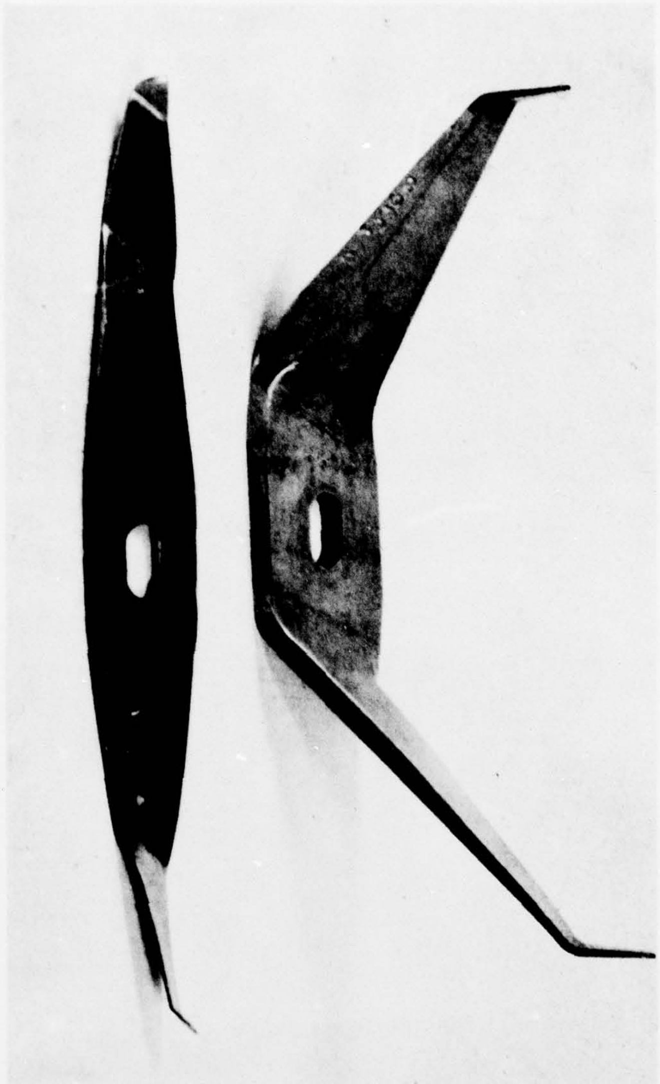
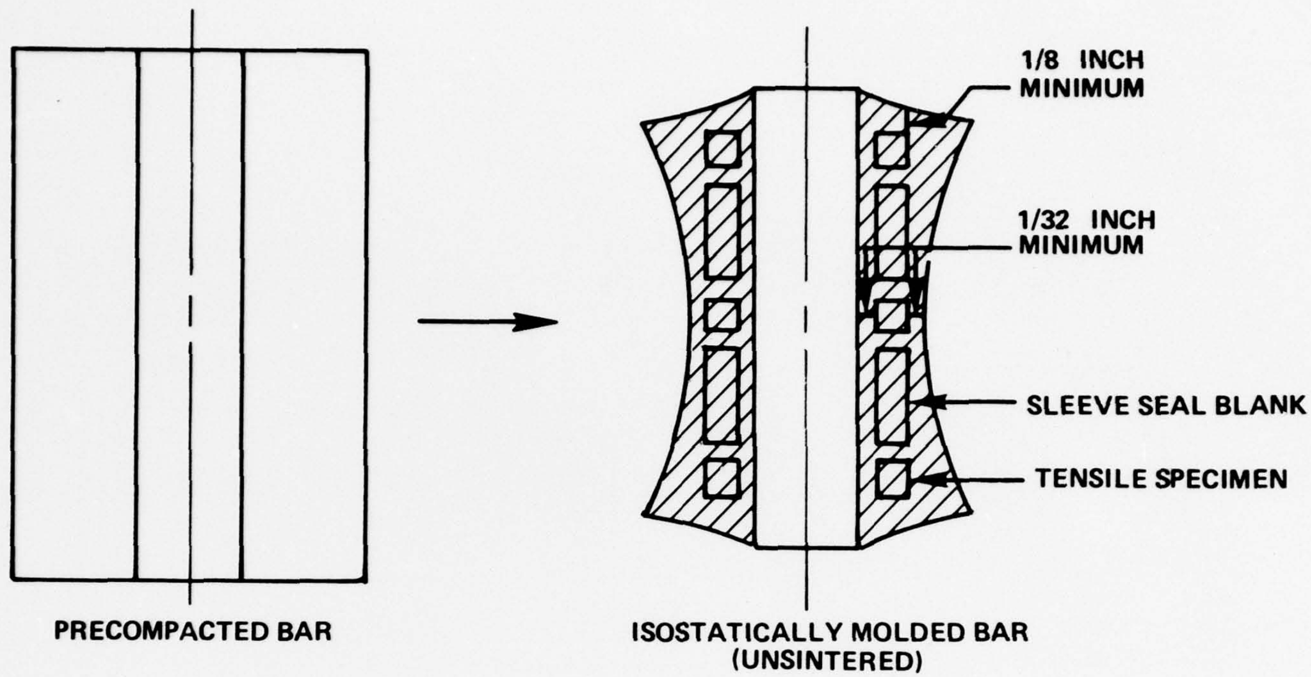


Figure 4 - Blender Blades



NOTE: TENSILE SPECIMENS AND SLEEVE SEAL BLANKS ARE MACHINED FROM SINTERED BAR.

Figure 5 - Precompacted and Isostatically Molded Bars

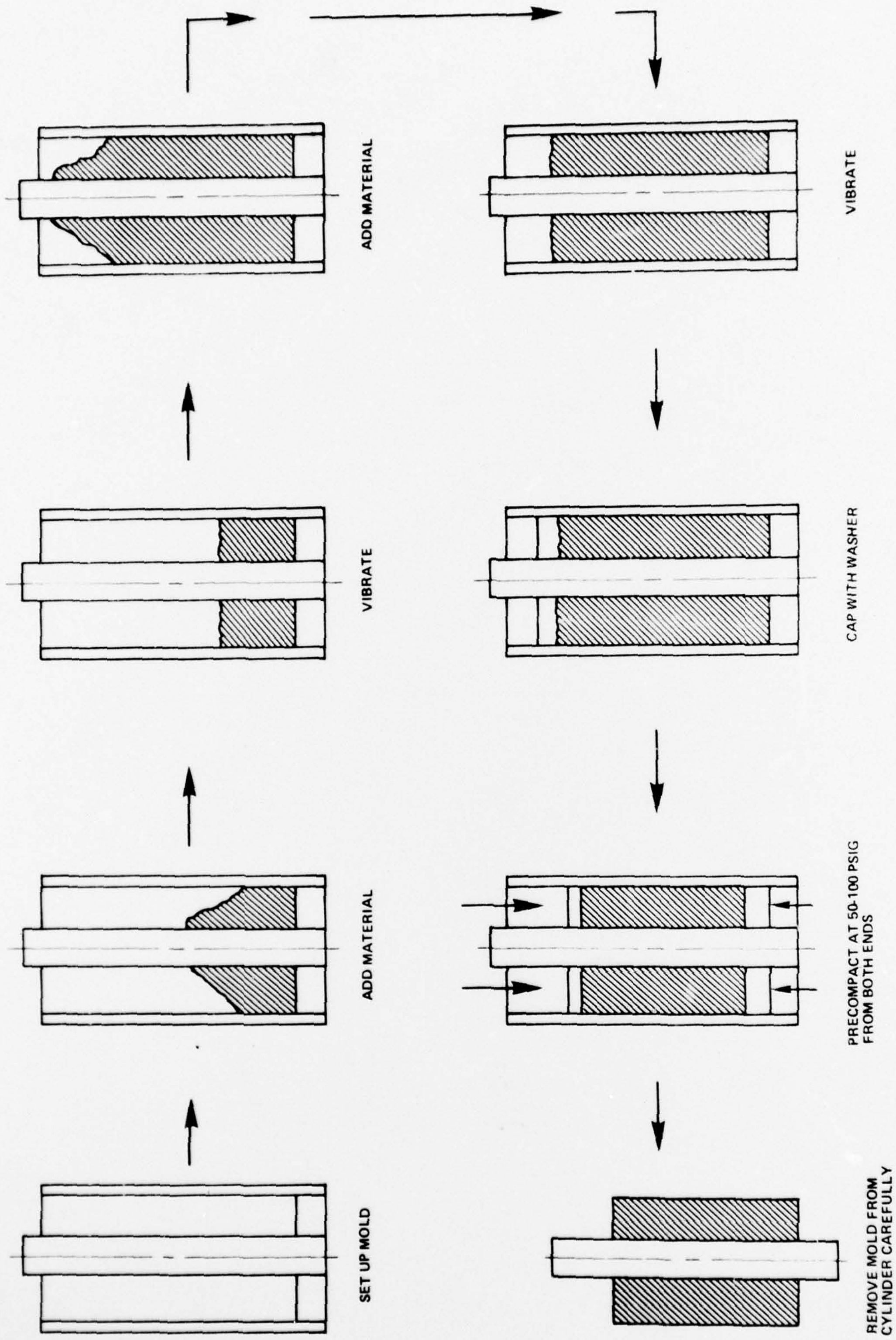


Figure 6 - Preisostatic Molding of Filled PTFE

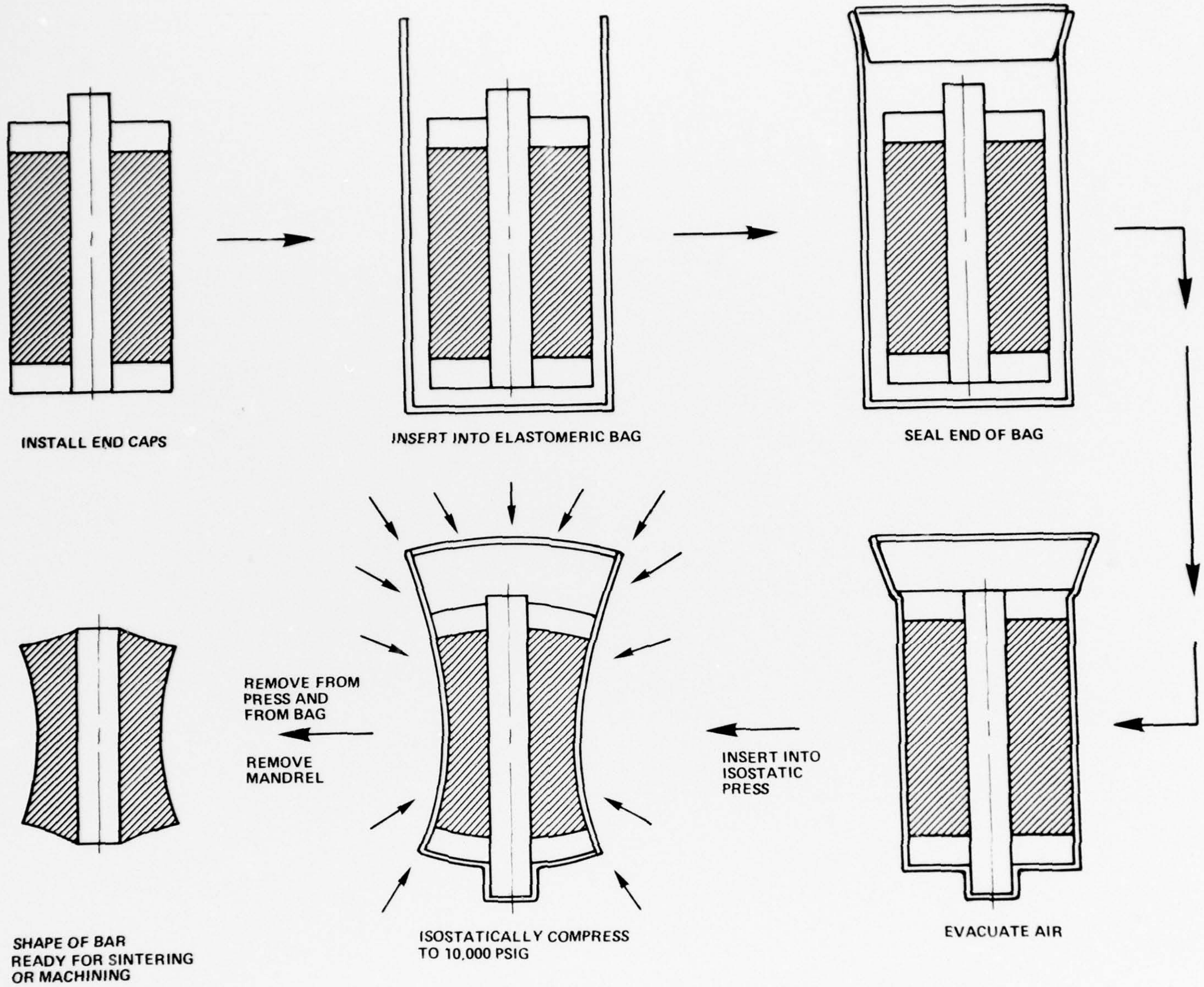


Figure 7 - Isostatic Compaction of Filled PTFE

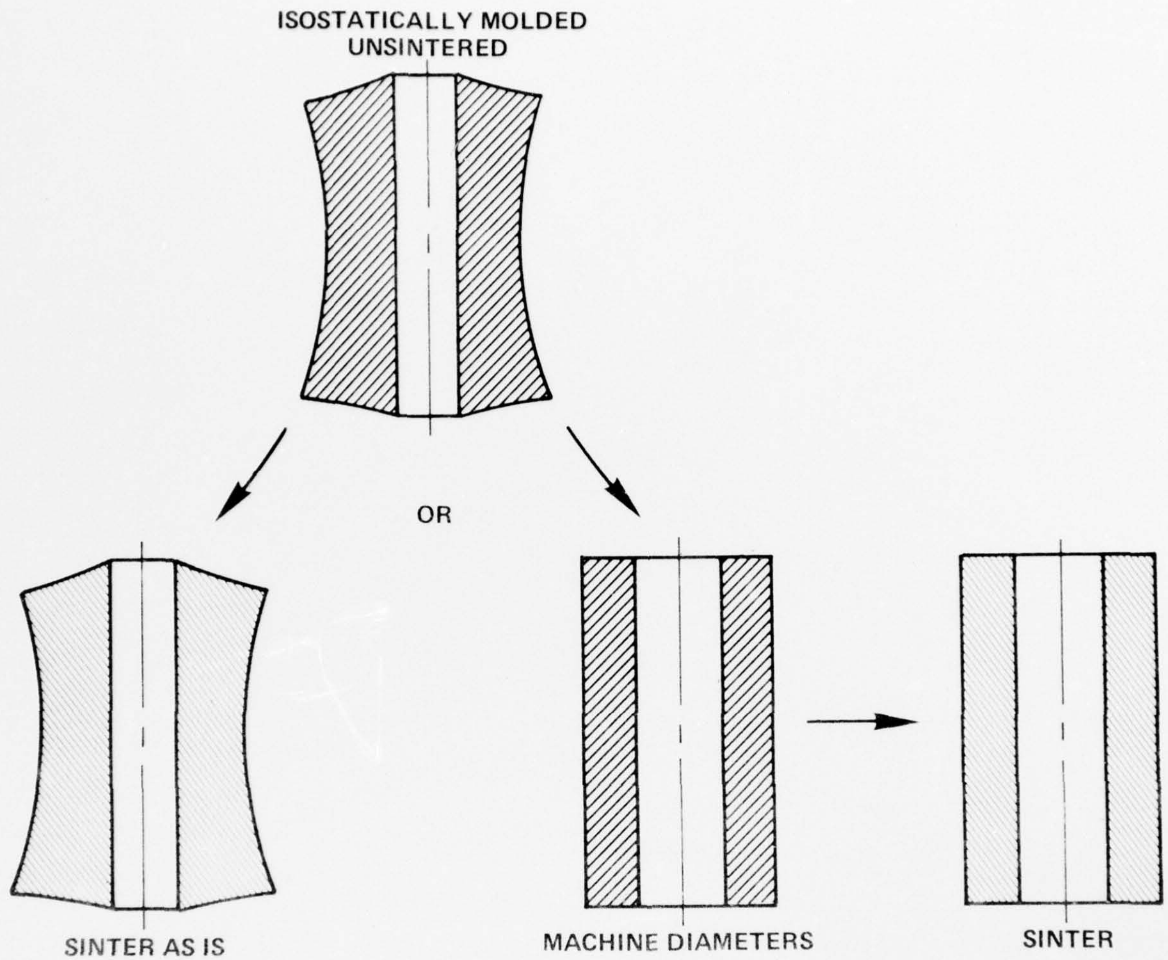


Figure 8 - Procedure Prior to Sintering Molded Bars

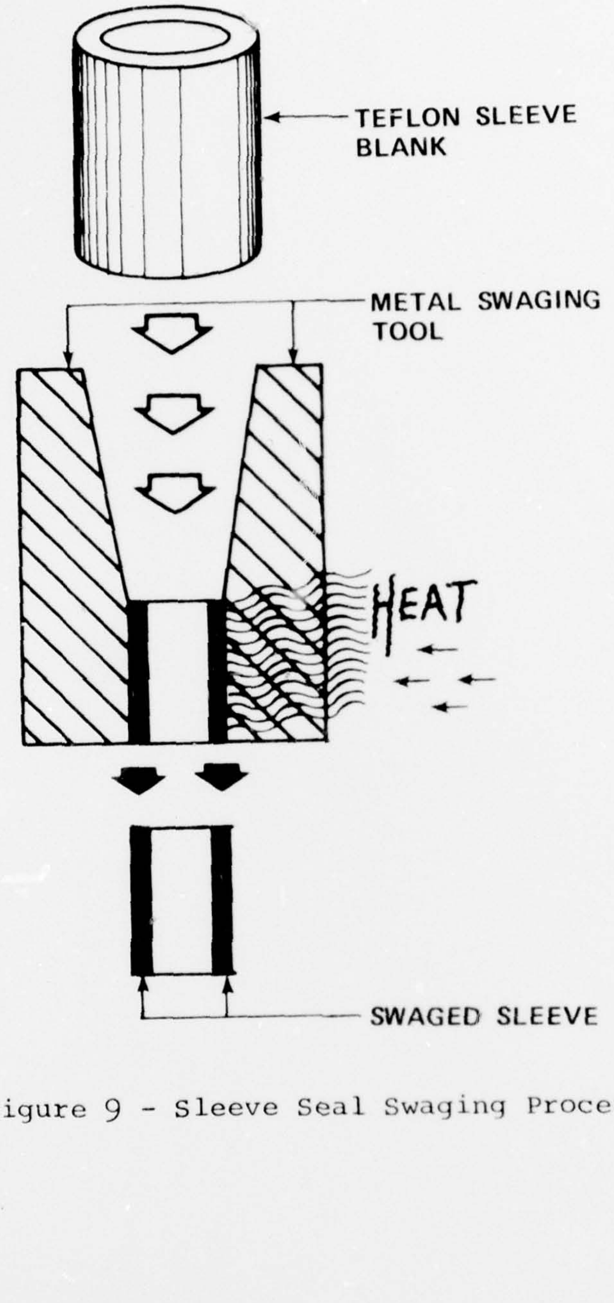


Figure 9 - Sleeve Seal Swaging Process

No.	Procedure
1	Throughout process, swaging tool and blank must be maintained at 110-140 F.
2	The blank should be pressed through swaging tool at a rate not exceeding 3 in/min.
3.	Using appropriate press plates and maintaining tool and blank alignment, press blank through tool until mandrel can be hand pushed but not dropped through partially swaged blank.
4.	Install mandrel so bevel extends past bottom of partially swaged blank.
5.	Install spacer on top end of partially swaged blank and around mandrel top.
6.	Reheat assembly and push against spacer until swaged seal contacts end cap.
7.	After assembling, tighten compression spring to 5-20 pounds of force. Do not fully compress spring.
8.	Heat treat assembly in vertical position, for two cycles. One cycle = 1 hour at 530 F and 1 hour air cool.
9.	When cool, remove from swaging tool.
10.	Machine radius and bevel on end last to enter swaging tool.

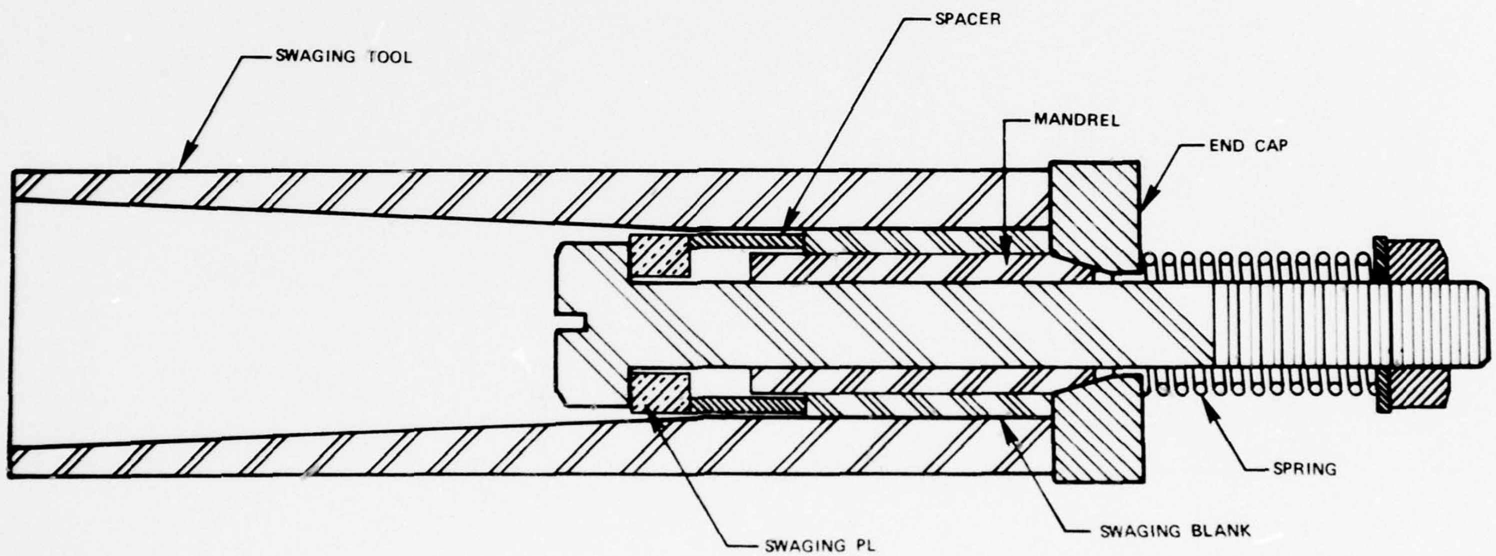


Figure 10 - Cross Section of Sleeve Swaging Assembly with Mandrel

No.	Procedure
1.	Throughout process, swaging tool and blank must be maintained at 110-140 F.
2.	Using appropriate press plates and maintaining swaging tool and blank alignment, press blank thru swaging tool and into blank holder. The blank should be pressed thru tool at a rate not to exceed 3 in/min.
3.	With blank at end of holder, assemble swaging plate, washer, rod, and spring around blank as shown. Compress spring to apply 10-12 pounds force. Important: Do not fully compress spring.
4.	While confined, heat treat two cycles. One cycle = 1 hour at 530 F and 1 hour air cool. During heat treatment, blank holder should be vertical with spring uppermost.
5.	Remove from blank holder.
6.	Before finish machining, relax swaged blank outside diameter to desired size by stress relieving in free state for 2 hours at 300 F. Air cool.
7.	Machine inside diameter and end of swaged blank as required. Machine radius on end last to enter blank holder.

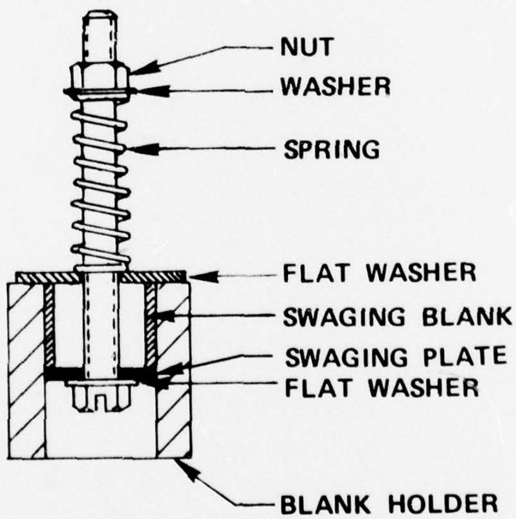


Figure 11 - Cross-Section of Sleeve Seal Swaging Assembly Without Mandrel

APPENDIX

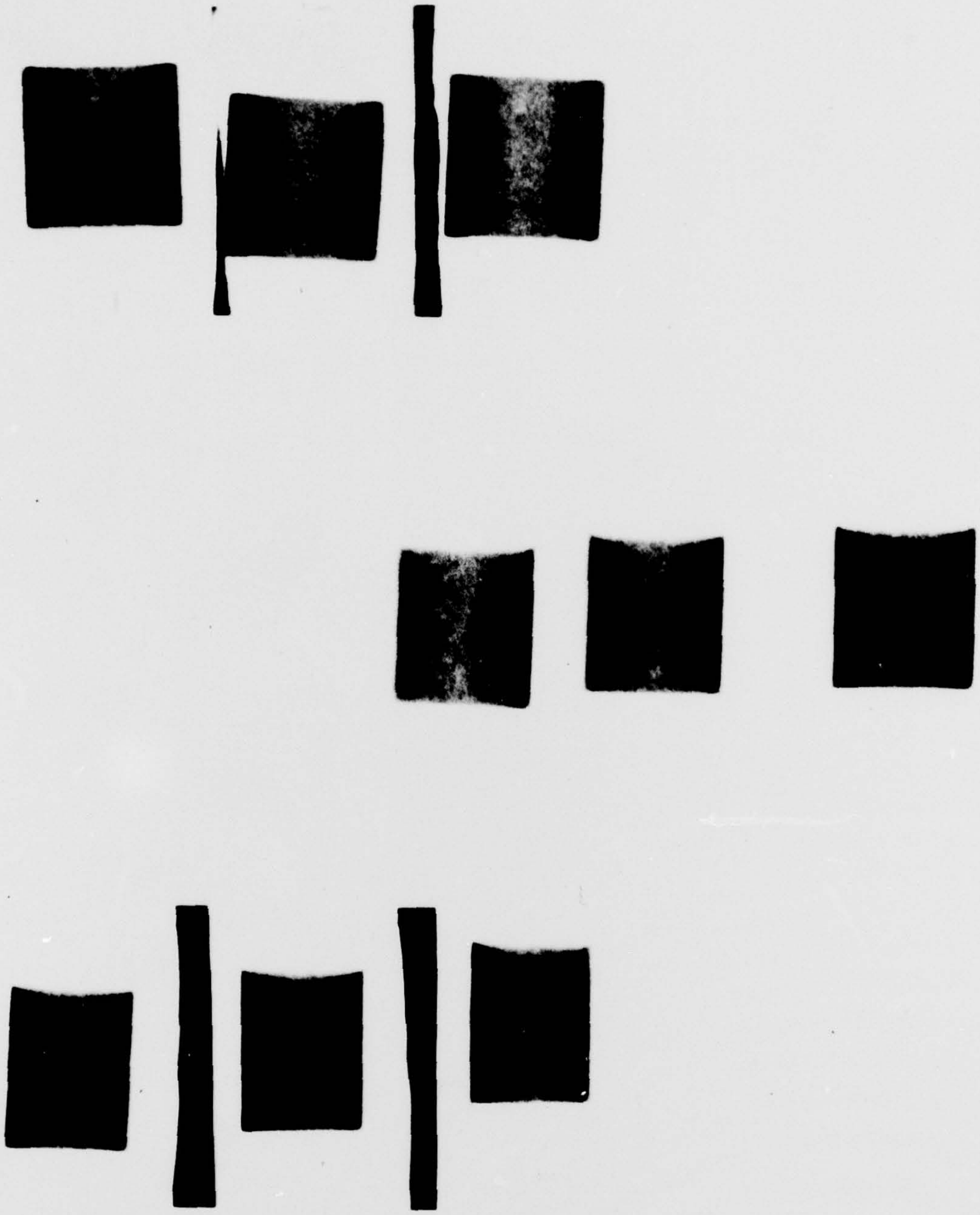
X-RAY INSPECTION TECHNIQUE FOR SLEEVE SEALS CONTAINING 35 PERCENT CHOPPED COPPER-WIRE AND 10 PERCENT GLASS-FIBER-FILLED PTFE

Metal-filled PTFE sleeve seals may be inspected by a "double-wall" X-ray procedure. After finish machining, the seal is placed on or against a sheet of film and exposed to radiation which has passed through the full diameter (two walls) of the seal. At least three exposures, rotated 120° apart, are required to properly inspect all areas of a seal.

Figures 12 through 15 provide radiographic examples of sleeve seals which are satisfactory, marginal, and unacceptable. These exposures were obtained using a Faxitron Model 805 X-ray unit and Polaroid type 52 film. Other X-ray units and films may produce satisfactory results. Exposure characteristics are dependent on the seal wall thickness and the seal material. In general, exposure times of 1 to 4 minutes, at 90-kilovolt peak voltage and 3 milliamperes, for a source distance of 23 inches, have been satisfactory. Since positive prints are shown in this appendix, the dark areas represent areas of heavy metal concentration, while the light areas represent voids or areas with little metal filler.

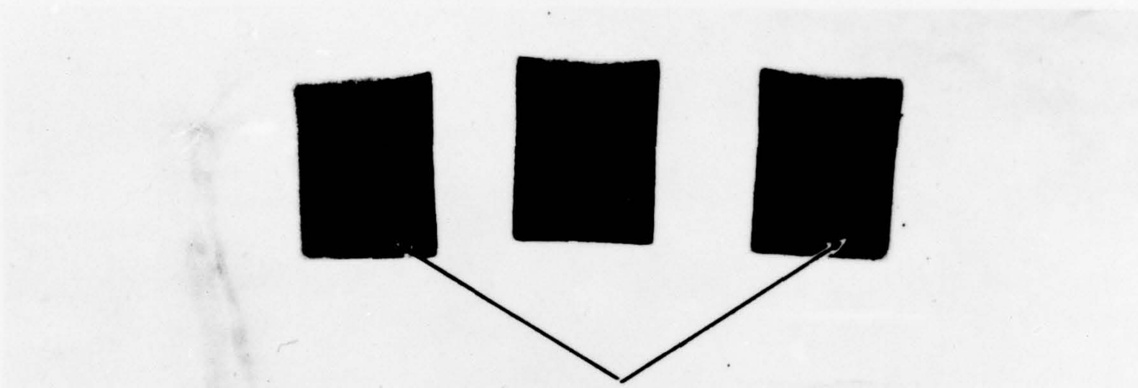
The radiographs of production sleeve seals should be compared with the examples. In order for a sleeve seal to be acceptable its radiograph should have the same appearance as the satisfactory material and be free of the noted defects. In cases where the filler dispersion is acceptable, but a defect is present, the sleeve seal may be acceptable if the defect is more than 7/16-inch from the sealing (radiused) end.

Information regarding these procedures may be obtained from this Center.



NOTE: Excellent Filler Dispersion, No Noticeable Voids, Material Acceptable

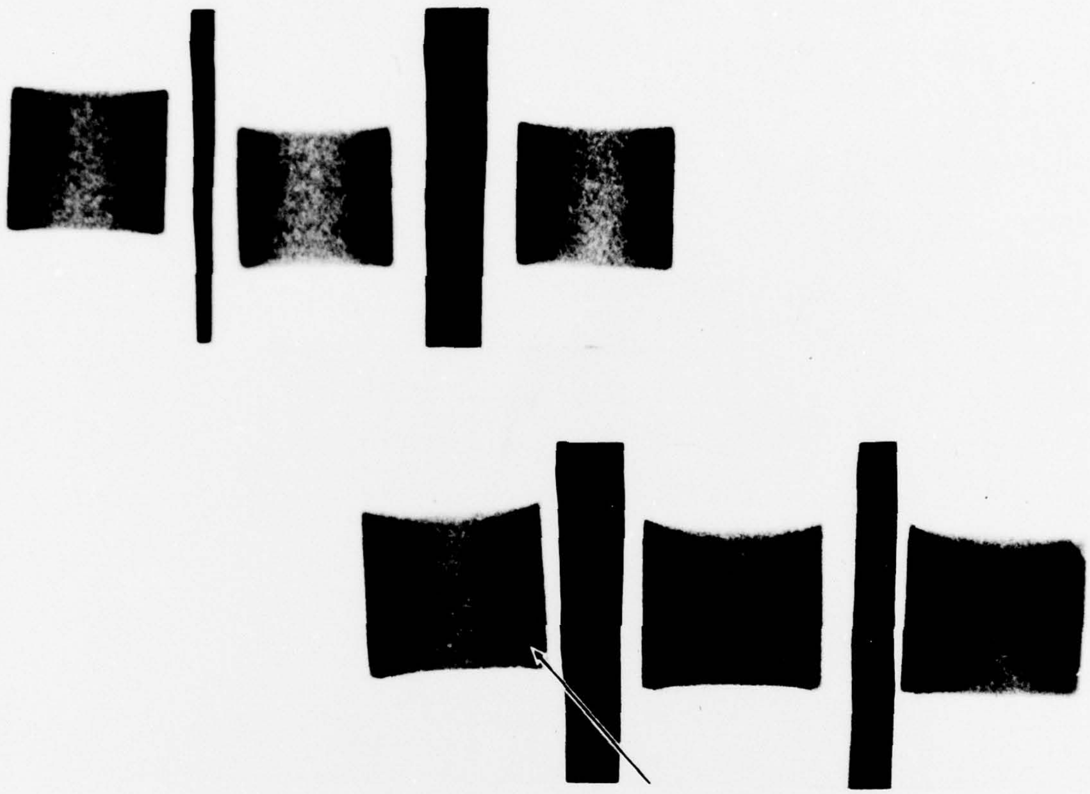
Figure 12 - Copper Wire Filled PTFE Sleeve Seals



Low Concentration of Metal Filler

NOTE: Marginal Filler Dispersion, Defects Noted. Sleeve Seal Acceptable Because Defect is More than 7/16 Inch from Wearing End.

Figure 13 - Copper Wire Filled PTFE Sleeve Seal



NOTE: Excellent Filler Dispersion. Defect Noted. Sleeve Seal Acceptable Because Defect is More than 7/16 Inch from Wearing End.

Figure 14 - Copper Wire Filled PTFE Sleeve Seals

NOTE: Poor Filler Dispersion. All Sleeve Seals Unacceptable.

Figure 15 - Copper Wire Filled PTFE Sleeve Seals